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TULIP BLOSSOM BLIGHT

By Frank Lincoln Stevens and O. A. Plunkett

A Blighted Tulip Showing Withering of Stalk and Woolly Growth of Mycelium on Diseased Part

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Fig. 1.—Healthy Tulip (center) and Two Blighted Tulips Showing Blossom Infection and Infection at Leaf Axil

TULIP BLOSSOM BLIGHT

By Frank Lincoln Stevens and O. A. Plunkett, in Cooperation with the Department of Horticulture[1]

Tulip blossom blight is a disease which manifests itself by a blighting and wilting of the flower stalk just below the blossoms, followed by a dropping over and collapse of the floral parts (cover illustration). In extremely damp weather and where there is an abundance of shade, the petals decay rapidly, becoming covered with a cottony mycelial growth, while the flower stalk undergoes a watery decay. The disease is caused by a fungus heretofore unreported in connection with this host.

The disease was first brought to the attention of the plant pathology laboratory at the University of Illinois in May, 1924, by gardeners in charge of the University grounds, who had found it present and destructive in a number of tulip beds. A survey of the tulip beds on the campus and in the surrounding territory has revealed the disease in only six beds on the campus and as prevalent only in tulips of the double varieties. In one bed, infection to the extent of 32 percent of the plants was found; in another bed, 26 percent. The causal fungus has been isolated from rotting stems and leaves of single varieties, but the typical blossom blight has not been observed on these varieties in nature.

GENERAL SYMPTOMS OF THE DISEASE

The first outward manifestation of this blossom blight of tulips is a shriveling of the flower stalk just below the flower, followed by a falling over of the blossom (cover illustration). The blossom then withers and dries up, or, if conditions are favorable for the disease, the petals become covered with the mycelium of the fungus and a rapid soft decay follows. The lesion at the base of the blossom is found to be shrunken and withered and of a yellowish-white color in contrast to the green of the normal flower stalk. There is also a tendency for the stalk or blossoms to twist at the lesions.

A second and less common method of attack of the fungus occurs lower down on the stalk, near the base of the leaf (Fig. 1). The symptoms here are similar to those described above. When infection

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takes place in the leaf axil, the leaves sometimes rot off at the base. If the tulips are growing in a very moist situation, and conditions are favorable for the disease, it may progress downward and rot off the entire stem. In most cases, however, the disease occurs as a lesion just below the blossom or at the base of the upper leaves.

FIG. 2.—TULIP BLIGHTED BY INOCULATING IN BLOSSOM

Study of a number of plants in various stages of infection showed that the fungus usually gains entrance thru the blossom, probably at the point of attachment of the petals, and advances into the stalk, causing decay and withering. In cases where infection occurs lower on the stalk, the fungus apparently penetrates thru the epidermis in the leaf axil.

INFLUENCE OF ENVIRONMENT ON THE DISEASE

From the observations made by the authors it appears that the prevalence of this disease is almost entirely dependent upon environmental conditions. The beds in which the disease occurred in abundance were all in damp, shaded situations. Beds in open and well-lighted and ventilated areas showed no evidence, or only slight evidence, of the disease. The mode of infection bears out the assumption that moisture is a necessary factor for prevalence of the disease. The double-blossom varieties hold moisture for forty-eight hours or more under usual conditions, while the single varieties dry out quickly. This, then, appears to be the reason that the double varieties are susceptible, while the single varieties, even in the same bed, are not. The unusual amount of rain during May, 1924, gave ideal conditions for the development of the disease.

THE CAUSAL ORGANISM

A practically pure culture of fungus was noted in the material first examined and in all newly collected material, and was found constantly associated with the typical disease. A large number of isolations consistently gave this fungus, either in pure culture or in great preponderance over any other growth. The isolations were readily made by planting bits of diseased tissue directly on poured corn-meal agar plates.

PROOF OF PATHOGENICITY

Inoculation No. 1.—Recently opened, double tulip blossoms, growing outside under normal conditions, were inoculated by placing at the base of the petals and also on top of the pistil pieces of corn-meal agar containing the fungus. At the end of six days the normal type of blossom blight resulted (Fig. 2).

Inoculation No. 2.—Tulips of a single variety were inoculated in a similar manner without positive results.

Inoculation No. 3.—Double and single tulips were inoculated under bell jars in a saturated atmosphere. All of these showed typical blossom blight at the end of three days.

Inoculation No. 4.—Blossoms of *Tradescantia spp.* were inoculated in an inoculation case, in a saturated atmosphere. None of the blossoms of this host became infected.

Inoculation No. 5.—Green tomato fruits were inoculated with the fungus by puncturing the epidermis. Ten days later there was a small rotten spot around the point of inoculation, but the remainder of the tissue remained firm.

Inoculation No. 6.—Growing stems of beans and growing radishes were inoculated in a moist chamber. Seven days later no signs of infection were visible.

Inoculation No. 7.—Iris blossoms were inoculated by placing among the petals chunks of corn-meal agar containing the fungus. The blossoms were placed in an inoculating chamber and kept in a saturated atmosphere for forty-eight hours. Five days later the blossoms had fallen over and the peduncles showed lesions similar to those on tulips.

FIG. 3.—BLIGHTED AND HEALTHY IRIS BLOSSOMS; BLIGHT CAUSED BY INOCULATION WITH A PURE CULTURE

The petals were soft and rotten. Uninoculated checks remained upright and healthy (Fig. 3).

Inoculation No. 8.—Growing gladioli bulbs were inoculated by puncturing the epidermis and by placing agar bearing the fungus on uninjured surfaces and on roots. The plants were kept under bell jars for forty-eight hours. There were no signs of infection either within the bulbs or on the roots.

Inoculation No. 9.—Seeds of cotton, flax, sugar beets, and onions were planted in six-inch pots. Corn-meal agar containing the fungus was mixed well with soil, and a covering one inch in depth was placed over the seeds. The soil was kept well moistened under bell jars. Damping-off occurred in pots containing sugar beets and flax. Check pots remained healthy.

In all cases where positive results were obtained from the inoculations, reisolations have been made and in all cases the fungus isolated proved to be identical with the fungus used in the inoculum.

DESCRIPTION OF THE FUNGUS

Mycelium

The mycelium is of the true Phycomycete type, being a long tube, irregularly branched, with few or no cross walls. Within the tulip tissue and in artificial media, the mycelium is, for the most part, thick and profusely branched, measuring from 2.5 to 11 μ in diameter. The hyphae are granular and slightly yellowish in color. In culture and on the normal host, the aerial mycelium is much finer and less branched than that within the host tissue or within artificial media. In culture, the mycelium sometimes becomes prominently warty, owing to the development of numerous small protuberances (Fig. 4).

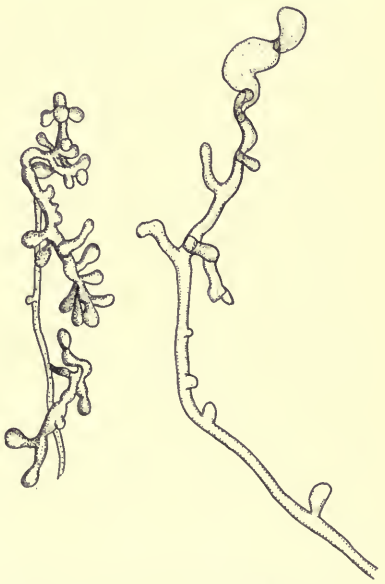

FIG. 4.—MYCELIUM FROM WITHIN THE MEDIUM, SHOWING COARSE AND KNOTTED APPEARANCE

Conidia

Conidia are abundant in cultures on oat-meal agar and are usually borne above the substratum, apically, on thin hyphae which branch off from the larger mycelium with the agar. The conidia are slightly variable in size and shape, but are comparatively large and short-ovate in form. They measure from 22 to 32 by 21 to 29 μ. Distinct papillae are always present on these conidia and are mostly apical (Fig. 5), tho occasionally a lateral one may be observed. They are about 3.6 μ in height by 5.4 μ wide. In rare instances two papillae occurred on one

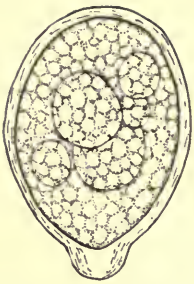

FIG. 5.—A SINGLE CONIDIUM, SHOWING PAPILLA

conidium. No intercalary conidia have been observed, and the conidia are never borne on the heavy mycelium but on thin branches. When placed in sterile, distilled water these conidia germinate by an ordinary germ tube which gives rise to the normal mycelium (Fig. 6). Repeated attempts to obtain zoospores have failed.

Oospores are abundant in pure culture and within the host tissues. They are spherical, ranging from 22 to 32 μ in diameter. The oospores are thick walled (1 to 2 μ), mostly hyaline, tho sometimes distinctly yellowish brown, depending upon the substratum. They are borne within oogonia, on short side branches of the thick, heavy mycelium inside the medium or host tissue. Antheridia are always present and are persistent and preponderantly paragynous. They may be borne on the same or on different mycelium from that of the oogonia. The antheridia are variable in shape, ranging from long curved tubes to irregular and spherical bodies (Fig. 7).

Chlamydospores have not been seen either in culture or in the normal host tissues.

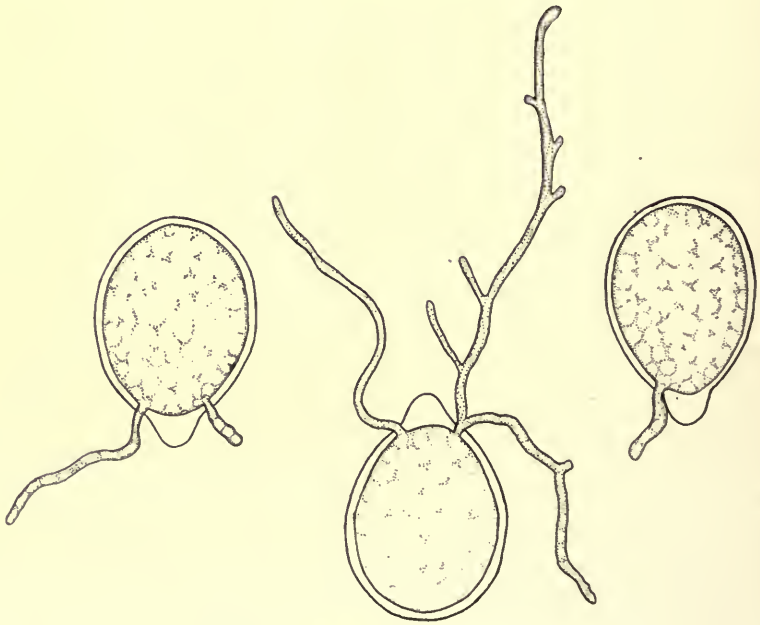

FIG. 6.—GERMINATION OF THE CONIDIA

OOGONIA

Oogonia are borne on short side branches on the large mycelium within or on the surface of the medium. In nature the oogonia are borne within the host tissue.

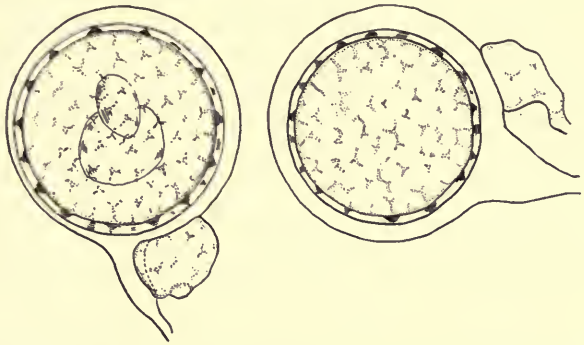

FIG. 7.—DRAWINGS SHOWING OOGONIA, OOSPORES, AND ANTHERIDIA

CULTURAL CHARACTERS

Growth on Corn-Meal Agar.—On corn-meal agar there is a translucent growth of the fungus, giving a granular appearance to agar. Here and there over the surface, flakes of white appear where aerial hyphae are sent up bearing conidia. The fungus penetrates up to 4 mm. in this agar and produces abundant oogonia at this depth. The mycelium shows more irregularity on this medium than on any other. Oogonia and conidia are not so abundant as on oat-meal agar. There is no aerial mycelial growth excepting the very short conidiophores which are sent up from within the medium. The conidiophores are much shorter on this medium than on oat-meal agar. Growth is very rapid, a colony occupying a plate within four to six days after inoculation.

Growth on Tulip-Stem Agar.—On tulip-stem agar the growth is similar to that on corn-meal agar, but not so abundant. There is no aerial mycelium and the mycelial development is entirely within the medium. The rate of growth is rapid, similar to that on corn-meal agar. No conidia are produced on this medium and the development of oogonia is not so abundant as on corn-meal and oat-meal agars.

Growth on Oat-Meal Agar.—On oat-meal agar the growth of the fungus, tho slower in spreading over an agar plate, is much thicker and the mycelium more abundant than on corn-meal agar. A thick weft of white, aerial mycelium is present. It is on this thin, white, aerial mycelium that conidia are produced in abundance. The aerial mycelium is produced in quantity only when the cultures are several days old and

are grown in the light. When grown in darkness, only a slight aerial mycelium is produced. Small, white, irregular spots that are granular are visible within the agar. These spots are masses of oogonia which are produced in more abundance on this agar than on corn-meal or tulip-stem agar.

Growth on Sterilized Vegetable Plugs.—An abundant growth of the fungus is produced on sterilized potato plugs, the mycelium forming a weft completely covering the plug. The growth is white and aerial mycelium is very abundant. Scattered conidia may be found within the aerial mycelium. Oogonia are produced in abundance on the mat of mycelium lying on and within the outer surface of the plug. Oogonial development is not so rapid as on carrot or bean plugs.

Growth of the fungus is more rapid on carrot plugs than on potato, but no aerial mycelium is produced. The surface of the plugs appears gray and powdered, as tho sprinkled over with meal. This powdered appearance is caused by the abundant clumps of oogonia. The mycelium forms a mat around the plug, penetrating the outer cells for a millimeter or so.

On green bean plugs the fungus grows rapidly, but only a small amount of mycelium is formed. Oogonia are produced earlier on these plugs than on potato or carrot but are not so abundant. Slight aerial mycelium is present at first, but as growth continues the bean tissue becomes watery and rots. Conidia have not been observed on this medium.

TAXONOMIC POSITION OF THE PARASITE

The morphology of the oogonia, oospores, and conidia clearly places this fungus as a Phytophthora. In this genus the preponderance of paragynous antheridia, the oospore measurements, and the preponderance of oospores in the early growth of the cultures show that it is closely allied to, if not identical with, *P. cactorum.* The characters given above make it impossible to regard the fungus as cospecific with any other known species. In view of its close similarity with *P. cactorum* it has been referred to that species.

SUMMARY

1. An hitherto unreported tulip disease is described.

2. The causal fungus is a Phytophthora which is referred to the species *P. cactorum*.

3. Its etiological relation to the disease was indicated by (a) its constant presence in the diseased tissue; (b) the absence of any other constant parasite; (c) proof of its pathogenicity by inoculation; (d) reisolation of the organism.

4. The disease is more common in humid, ill-ventilated situations.

5. It is more common on double than on single blossoms, apparently because of humidity differences.

6. Iris was susceptible to inoculation.

RECOMMENDATION

The only suggestion which can be made as to the prevention of the fungus is the avoidance of situations that are especially humid.

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